

ROTARY QUERNS AND MILLSTONES FROM THE THERMENTERREIN SITE IN HEERLEN – THE NETHERLANDS

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Introduction

The Thermen museum contains an important assemblage of rotary querns and millstones mainly from Heerlen and the archaeological excavations of the bath district.

This type of objects have often suffered from disregard and are only recently the object of precise registering according to their stratigraphical context. The examples from the Thermen museum are not an exception because 5 querns and 4 larger millstones are totally devoid of provenance information. 41 other pieces come from different places in Heerlen, mainly from the city centre but will not be part of this chapter. 10 quern and millstone fragments coming from the excavation of the baths are finally taken into consideration. However, for these documented finds, the archaeological context corresponds to a reuse of the fragments in masonry, combustion structures or as whetstones. This explains why their manual, animal or hydraulic driving mechanisms are not identified. Yet the proportion of querns and millstones and their presence in the bath district gives a fairly reliable overview of the milling practices of the town.

Querns and millstones are tools of daily use to process food. They are essential to the life of an organised society, and are thus placed at the centre of major socio-economic issues. The society which saw their invention and development is responsible for this technical progress by necessity and emulation. After the millenary use of the saddle quern driven with a to-and-fro motion, the emergence of the rotary mill answers the needs of a growing population, fruit of profound socio-economic and technical changes which characterise the European Late Iron Age.

The oldest rotary hand mills are recorded in the north-east of the Iberian Peninsula and date to the beginning of the 5th century BC (ALONSO-MARTINEZ 1997). From this region, the innovation is transmitted by imitation in Southern Gaul, and reaches Northern Gaul during the second half of the 3rd century BC. In the Rhine and Meuse deltas, the first examples are found in mid 2nd century BC contexts.

The arrival of the Romans in *Germania* at the end of the 1st century BC and the stabilisation of the *limes* in the first half of the 1st century AD induced an intensification of the quern quarries in the Eifel volcanic massif, and peculiarly in the Mayen area (Rhineland-Palatinate, Germany). The Mosan and Mosello-Rhine markets were literally flooded of rotary querns and millstones hewn from basalt-like lava. At this period, the milling process switched from the domestic sphere to the specialised craft and commercial environment. Yet milling for domestic subsistence remains very dynamic, as evidenced by the many small hand querns found in Roman-Germanic settlements.

Other materials besides volcanic rocks (yet poorly represented at Heerlen) were specifically chosen in Roman times in the Ardennes Massif for quern making. A coarse beige to grey sandstone, originated from lower Devonian geo-stratigraphic levels, is frequently employed for this use in northern Gaul and sometimes found on Roman sites in Lower Germany (2 examples in Heerlen). Another Devonian coarse sandstone (arkose) rich in feldspar is usually found in large animal driven millstones discovered in rural contexts in Netherlands, but is very little present in the Heerlen collections (1 fragment).

1 THE ROCKS TYPES

Before use, querns and millstones were extracted, fashioned and transported from manufacturing workshops to the consumption sites. Rock analyses are thus essential to understand of ancient trade patterns.

For sedimentary rocks, a simple macroscopic observation by eye or binocular loupe is most often enough to categorise and determine the age of the deposit. Consulting the geological map is then required to pinpoint the formation.

Simple macroscopic observations in the case of volcanic rocks are not enough to specify the precise origin of the deposit, and it would be necessary to carry out geochemical XRF studies to identify the major and trace elements (GLUHAK, HOFMEISTER 2008, 2009, 2011). However, these types of analyses can only be carried out on artefacts found in clear and reliable archaeological contexts and are of little interest for millstones coming from ancient excavations.

In Heerlen, the querns are typologically comparable to products from the Eifel (MANGARTZ 2008 and 2012). The location of Heerlen therefore makes very probable their import from the Rhenish area rather than from the other large European volcanic districts (Lovosice in Czech Republic, French Massif Central, Agde in Southern France, Orvieto, Mount Vulture and Vesuvius in mainland Italy, or Etna in Sicily...).

Consequently and without XRF analyses, we will only be able to talk about the production of the Eifel region, the most likely origin of the Heerlen artefacts.

1.1 Basalt-like lava

The volcanic rocks observed at the Heerlen museum are dark grey, vesicular (1-4 mm), containing a small quantity of black augite crystals and translucent xenoliths in the vesicles.

The rocks available in the quaternary volcanic flows of the Eifel massif are of different types and cannot be discriminated by eye (foidite, tephrite/basanite, basalt, trachy-basalt, trachyandesite, basaltic trachyandesite, phonolite, phono-tephrite...: GLUHAK, HOFMEISTER 2011). Here, without detailed analysis, we retain the generic term of basalt-like lava.

Publications concerning the Eifel productions and quarries are countless. In Antiquity, the volcanic rocks from this region were indeed exported over hundreds of kilometres in the form of querns and millstones in the Mosello-Rhine Basin, a part of the Meuse Basin, along the coast of the North Sea and relatively far inland along the Thames basin in Britain (GLUHAK, HOFMEISTER 2011 ; PEACOCK 2013). In Heerlen, basalt-like lava is widely predominant (95.5 %), coming from an absolute distance of 120 km. From the commercial harbour of Andernach on the Rhine River, the goods produced in the Mayen quarries were freighted down the river until the North Sea and shipped up the Meuse. It is however likely that some merchandise was unloaded in Bonn or Cologne (Köln) before being sent to Heerlen, Maastricht and Tongeren by the main road leading to Bavay and Boulogne-sur-Mer (France). For medium distance distribution these products can also be transported by land while fluvial transport would be preferred for long distance trade.

1.2 The true « arkose »

Only one millstone fragment is hewn from coarse sandstone. This rock is poorly cemented and contains a large amount of more or less weathered feldspar crystals and a few centimetric lithoclasts and pebbles of quartzite, quartz, sandstone, argillite and schist. Its high proportion of feldspar allows us to classify it as an arkose.

The geological and geographical provenance of this rock is highly uncertain. It could be found to the east of the Rocroi Massif (Ardennes) and could match with a specific facies of the Oignies formation from the Lochkovian stage of the Lower Devonian (HARTOCH *et al.* 2015).

Two other querns kept in the museum but of undefined origin within Heerlen are identified as Macquenoise production. They are made of coarse grey sandstone containing few amounts of tourmaline crystals and known as Macquenoise sandstone (Lochkovian, Lower Devonian). Their

provenance is located west of the Ardennes massif, on the French/Belgian border, where large quern quarries were exploited during Protohistory and Roman time (PICALET 2011; PICALET *et al.* in press; PICALET *et al.* submitted).

2 TECHNICAL ASPECTS OF QUERNS AND MILLSTONES

Throughout all of Protohistory, mills were operated by hand. The invention of the rotary mill during the Late Iron Age has no effect on this practice, in spite of increasing the yield and reducing the investment of time.

The first animal or human mills driven from a standing position appear in Spain during the 5th century BC (ALONSO-MARTINEZ *et al.* 2016), and Pliny places the first bakeries in Rome by the middle of the 2nd century BC (Pliny, *Naturalis Historia*, XVIII, 38, 1). These bakeries operated the celebrated biconical Pompeian-style mills, well represented in the Roman cities of Pompeii and Ostia (BAKKER 1999). Similar models are found throughout the Roman Empire and even in the provinces of Gaul, Germany, Iberia and Britain. They are evidence of the installation of Roman-style bakeries in Romanised territories (JACCOTTEY, LONGEPIERRE 2011; MAUNÉ *et al.* 2013; ANDERSON *et al.* 2016; PEACOCK 2013).

By the end of the 1st century BC, Vitruvius described a water-powered mill equipped with a complex gearing system that drives an upper millstone by means of a vertical central shaft (Vitruvius, *De Architectura*, X, 5, 2). Water-powered mills are becoming more and more frequently finds in Western Europe. The 1st century industrial milling factory of Barbegal (Bouches-du-Rhône, France) aligned two rows of eight stone built mills fed by an aqueduct. These mills provided the supply of flour to the city of Arles (France) (LEVEAU 1996). It is also becoming apparent that rural villas were frequently equipped with small wooden or stone built mills. Although they leave very few traces, they are being identified thanks to more and more efficient investigative methods (CASTELLA 1994; BRUN & BORRÉANI 1998; ANDERSON *et al.* 2004; JACCOTTEY, ROLLIER 2016).

Although there is no doubt as to the animal driven mill, the adaptation of the Vitruvian mechanics to the animal traction remains uncertain. Draught animals such as mules, horses, or oxen could drive a vertical shaft equipped with a rynd at its end that drives the *catillus*. Gearing applied to this mill can also multiply the speed of rotation. The archaeological remains of this hypothetical mill are very difficult to interpret and this system can only be assumed on few archaeological sites (NEAL 1996; PEACOCK 2013). However, the first texts recording this technique are not introduced before the 13th century (COMET 1992).

The main argument defended by D. Baatz is that there is no evidence that hydraulic-like millstones at plateau sites like the Roman fort of Zugmantel (Germany) are associated with running water either in the form of a natural watercourse or an artificial aqueduct (BAATZ 1995). The discovery of circular traces of trampling is another good indication if these mills are associated with millstones driven in their centre or millstones driven in their periphery.

In face of this problem, it is the millstones themselves that are the main evidence of the practice of milling and its scale. According to the Latin authors, the upper mobile stone is called the *catillus* and the lower stone is called the *meta*.

The *catillus* bears the technical fittings which enable a rotary movement and lead to identification of the mill type. Different morphological and technical analyses serve to classify them as hand querns, with a diameter generally lower than 50 cm, and larger millstones with a diameter greater than 50 cm. The observation of technical features comforts the division between “Vitruvian” mechanisms driven from the centre and devices equipped with lateral features meant for peripheral traction.

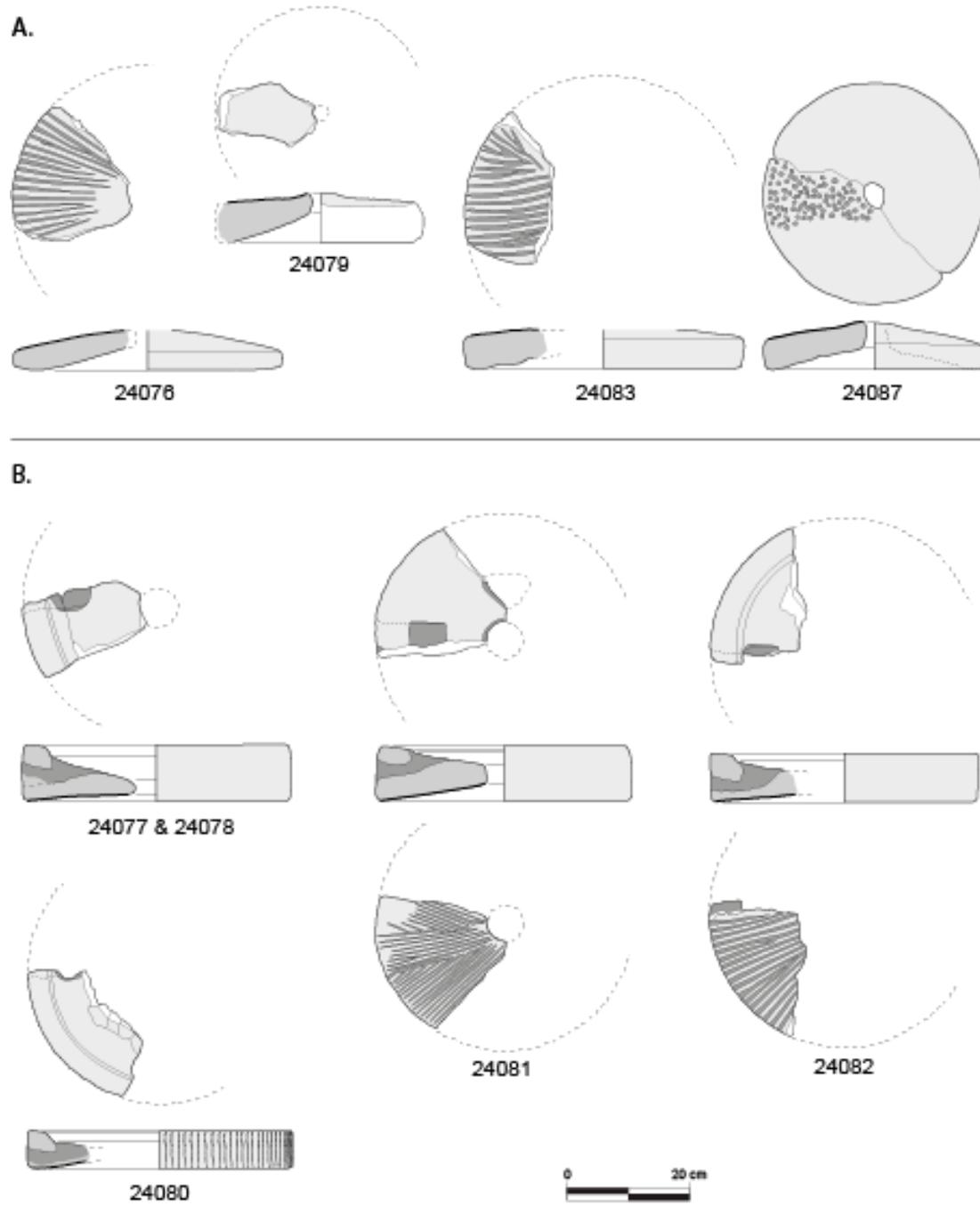


Fig. 1 – Roman querns made of basalt-like lava. Drawings and CAD scale 1/10 (P. Picavet)

2.1 Hand operated rotary querns

2.1.1 Morphology

The majority of milling stones found in the bath area present a diameter less than 50 cm, more exactly between 35 and 46 cm (8 querns of the total of 10 cases where the diameters can be estimated). All are made of basalt-like lava. By comparison, the other querns found in the city of Heerlen are between 32 and 49 cm.

The *catilli* (upper running stones – fig. 1B) are cylindrical in shape with two opposite concave faces and an upper face marked by a flat rim (fig. 2). This shape is ascribed to the vast Roman exploitation of Eifel quarries dating from the middle of the 1st century AD.

Metae (fig. 1A) are more difficult to characterise. Some can be distinguished by flat or hollowed bases, criteria that nonetheless do not serve for dating as both types are contemporary during the Late Iron Age (WEFERS 2006) and later during the Roman period in Germany (MANGARTZ 2008).

Another feature of *metae* is the convex use wear of their grinding surface corresponding to that of the *catillus* resulting from the absence of a tentering system, that is, the upper stone was in direct contact with the lower stone. This wear is even more pronounced in the case of the smaller La Tène or early Roman querns than the later Roman models. This could indicate a technical evolution in the fittings and the way the two stones were assembled. This suggests that the *catillus* above the *meta* was driven freely in the early period, but centred and supported by a rynd thereafter. This difference of wear of the active surfaces has been noticed between fast rotating water millstones and slowly rotating animal millstones in southern France (LONGEPIERRE 2012).

2.1.2 Driving the handmill

The handle hole on the *catillus* is elbow shaped. That is, it is cut into the edge of the quern and extends to the upper surface (type 4 defined by the french *Groupe Meule*). This type is found throughout the north-east of Gaul and Lower Germany: (JODRY *et al.* 2011). A wooden or iron fitting, a ring or a flexible link is inserted into this hole to drive the mill.

A series of basalt-like lava querns found in the Roman fort of Newstead in Britain at the beginning of the 20th century were still equipped with iron spindles emerging from the elbow-shaped holes by the flank as horizontal rings. These fittings served to insert a vertical handle (CURLE 1911, pl. XVII).

2.1.3 Feeding the hand mill

Other peculiar perforation is found on *catillus* 24081. The cutting is triangular and placed adjacent but independent from the eye. This position is opposed to the querns of this type found in Gaul, where both communicate directly (ROBIN & BOYER 201; PICAUVET 2011). These triangular holes are characteristic features of querns in Lower Germany and could have served to feed hulled grains into the mill to simultaneously dehusk and grind (BAATZ 2010; HARTOCH *et al.* 2015). In this case, the circular eye would only retain centering function, lodged with a simple rynd.

2.2 Geared millstone driven from the centre

2.2.1 Morphology

One millstone made of basalt-like lava shows a diameter and technical features which serve to classify it as a millstone driven from its centre. It's a *catillus* that measures 80 cm diameter. Five others of these large millstones come from an area comprised within a radius of 100 m around the baths, and four are kept in the museum without provenance. When measurable, their diameter is between 56 and 80.5 cm.

The thickness of a millstone is a very relative criterion linked to its degree of wear. The millstone coming from the baths area is relatively thick (13.8 cm) compared with the other pieces of the city (between 9 and 12 cm for the *catilli*).

A piece of iron is sealed with lead in the upper face of the *catillus* and is the remaining part of a ring intended to lift the millstone for its maintenance. Two complete rings of this kind are kept into the museum but come from old excavations and have no precise provenance in Heerlen.

2.2.2 Driving large mills

The dimensions of this millstone imply non-manual system of traction requiring more efficient source of energy. On one hand, the fragment does not bear lateral handle hole, excluding a peripheral means of traction. On the other hand, a dovetail-shaped cutting is carved in the active surface beside the eye. This cutting is meant to lodge a double dovetail iron fitting, the rynd, serving to transmit the energy from the shaft to the millstone. This piece also serves to lift and disengage the catillus over the meta in order to start its rotation without breaking the mechanism. A dosage cone, such as the one exposed in the museum, has to be placed at the top of the axle to open and close the hopper and adjust the grain distribution (BAATZ 1994 ; FORT, TISSERAND 2016).

This model of hydraulic mill was described by the Latin author Vitruvius at the end of the 1st century BC. He details a complex system of water-power enhancement for grain milling which increases the yield and frees women of a tedious domestic task:

“Water mills are turned on the same principle [as the water-lifting machine]. Everything is the same in them, except that a drum with teeth is fixed into one end of the axle. It is set vertically on its edge, and turns in the same plane with the wheel. Next to this larger drum there is another one, also with teeth, but set horizontally; in the middle of this small drum is an axle at the end of which is attached a dovetail-shaped iron piece inserted into the millstone. Thus the teeth of the drum which is fixed to the axle make the teeth of the horizontal drum move, and cause the mill to turn. A hopper, hanging over this contrivance, supplies the mill with corn, and meal is produced by the same revolution.” (Vitruvius, *De Architectura*, X, 5, 2)

Based on the same model, it is possible to imagine a system of traction by animal driven from the centre of the millstone, but as stated above, this system is not really certified historically and archaeologically before the 13th century.

Furthermore, even if the water supply system in Heerlen is not known, the presence of a bathhouse on top of a hill with no natural watercourse implies the existence of an aqueduct. This kind of water supply is the favourite system for urban watermills in Roman Italy (BRUN 2007) and for the battery of mills of Barbegal (Bouches-du-Rhône, France).

Moreover, the Latin author Palladius, at the end of the 4th or the beginning of the 5th century AD, mentions an important custom in the organisation of the rural *villa*, that can be applied in town in some cases:

“If water comes in abundance, ensure that the overflow of the baths reaches bakeries. It will set in motion the mills established there, and you will be able to grind wheat without the need of human or animal labor.” (Palladius, *Opus agriculturae*, I, 42)

In all, six millstones corresponding to hydraulic types were discovered on different sectors around and downhill the baths (Coriovallumstraat - Thermen and Zwarte Velde -, Uilestraat, Dr. Poelsstraat, Nobelstraat). The precepts that Palladius espouses in the Late Roman period seem likely to have prevailed during the Roman occupation of the town.

2.3 Animal driven mill

A fragment of a large *catillus* made of true arkose presents driving system which implies a peripheral traction. It measures 78.5 cm in diameter and 7.2 cm in thickness, and has a grinding surface with a low inclination (6°) more or less parallel to its upper face. A vertical hole 3.5 cm diameter is cut 16.5 cm from the edge and serves to attach of a driving system.

The first reflex would be to link this *catillus* to the Avenches-type hydraulic millstones (Switzerland: CASTELLA & ANDERSON 2004; BUCHSENSCHUTZ *et al.* 2016), with sockets that lodge iron crampons sealed with lead and connected to a central shaft serving to transmit the power of traction. However, the high recurrence of this type of millstone in Belgian Gaul and Lower Germany as well as the traces of wear of the holes point to a system to fix a lever to drive the mill with peripheral traction.

This type of simple but large millstone is above all recurrent on rural settlements such as large *villae* and small farms (PICAVET 2016). It is indeed present in the Roman non-*villa* rural settlement excavated on the outskirts of Heerlen before the installation of the Trilandis Europe business park (TICHELMAN 2014). There both small basalt-like lava hand querns and large millstones of true arkose have been discovered. They also are present in some secondary agglomerations with mixed urban/rural economic model like Famars (France), Liberchies or Tavieres (Belgium). Yet they are absent or almost absent from large cities and other towns with purely urban economies like Arlon (Belgium) or Heerlen (only 1 fragment). They correspond to mills acquired to meet specific needs linked to agrarian activities like the dehulling of hulled wheats as suggested by D. Baatz (BAATZ 2010), or the grinding of fodder for livestock (PICAVET 2016).

This fragment differs from another made of basalt-like lava found to the north, outside the baths (Zwarte Veldje) and also driven by peripheral animal traction (90 cm diameter). This last fragment is part of a “Haltern-like” mill, often found in military camps along the *limes* for food processing of the army. Known from the Augustan period to the middle of the 1st century AD, this model is the Germano-Roman equivalent of the biconical “Pompeian-like” mill found in the bakeries throughout the Roman world (BAATZ 1995).

2.4 Surface treatment

Querns and millstones made of basalt-like lava show two sorts of fashioning marks according to if they are placed on active or non-active nature surfaces. The bowl-shaped upper face of hand driven *catilli* is carved with thin parallel lines arranged in perpendicular sectors. These lines are extended to the rim with a spacing every 10 mm. Identical vertical lines with the same spacing are also systematically carved on the outer edge.

These chisel marks are not functional but ornamental. They serve as a trademark of a part of the Eifel quarries as these designs are extremely prevalent on productions disseminated throughout Belgian Gaul, Germany and Britain.

Hydraulic-like millstones also show a peculiar decor, but made differently. It's only partly preserved on the fragment coming from the baths area, but some complete pieces found elsewhere in the town show an entire drawing (fig. 7A). The flat upper face of the *catillus* is decorated with two interrupted half circles forming a *pelta* (shield symbol) around the eye. This motif is sometimes complemented by an inscribed circle. This drawing reserves the space of two iron rings maintained by lead and intended to lift the *catillus* above the *meta* to carry out maintenance of the grinding surfaces. The upper face and the edge are also finely finished with a pickaxe.

No hydraulic *meta* has been found in the baths area; elsewhere in Heerlen their non-grinding surface, not intended to be seen but to supporting the mill, is coarsely carved with a chisel or a pin stonemason and shows no signs of a fine finishing.

The treatment of the grinding surfaces called “dressing” is different at all levels. On the technical side, it limits the wear caused by the contact between the stones and the ground product. Millstone dressing has to be carried out regularly so as to maintain the quality and the “bite” of the rock.

In one case (24087), dressing design takes on the form of a honeycomb; this quern probably broke during its redressing that remains unfinished. In the other cases, it takes on the form of a pattern of straight furrows in regular sectors, radiating from the central eye. This pattern is widespread within *Civitas Tungrorum* (HARTOCH *et al.* 2015) but differs from the “complex straight furrow” pattern usually observed in Belgian Gaul (LEPAREUX-COUTURIER 2013).

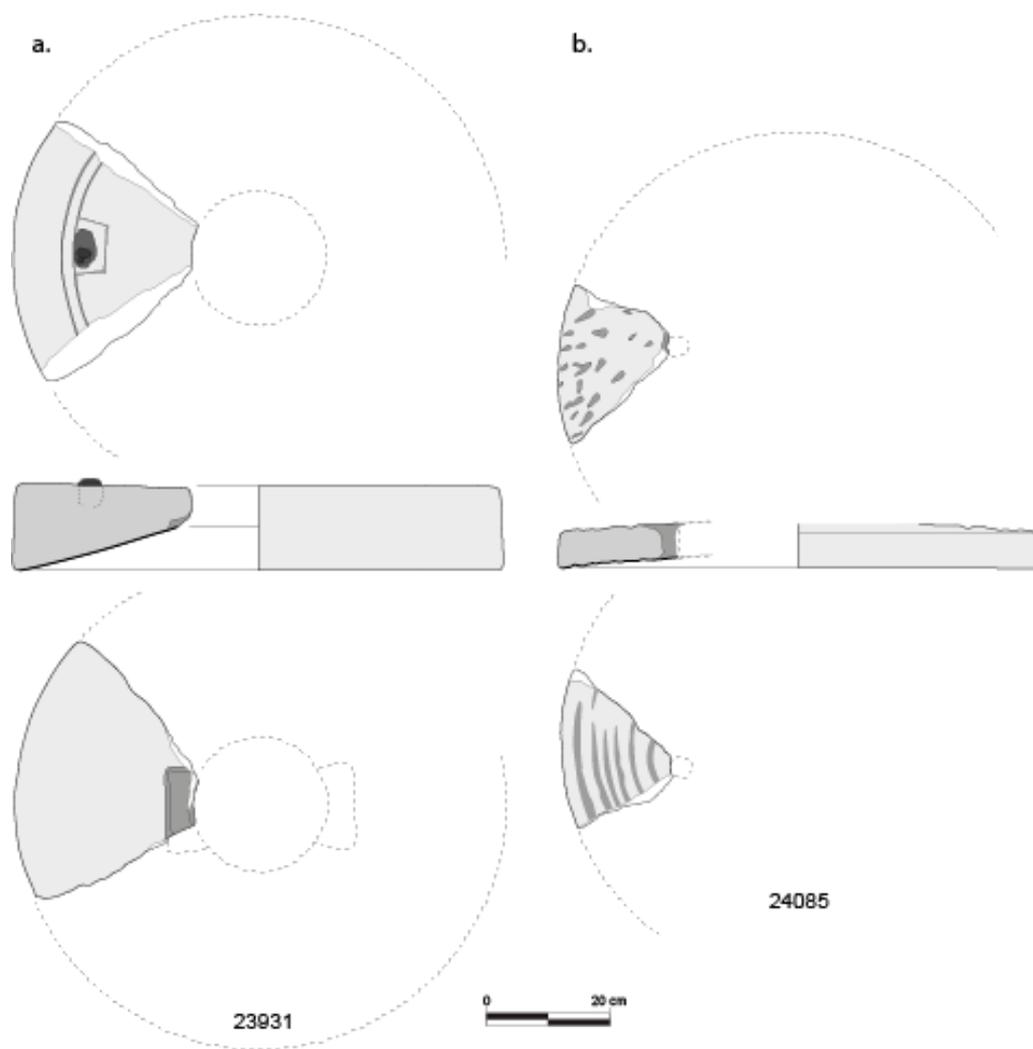


Fig. 2 – Large Roman millstones, found at the Thermenterrein site. Drawings and CAD scale 1/10 (P. Picavet):

A. « Hydraulic » millstone made of basalt-like lava. N° 23931

B. Animal driven millstone made of coarse arkose. N° 24085

3 CONCLUSION

The querns and millstones coming from the baths area constitute a coherent series for this period and allow us to approach the milling practice of a Roman town close to the *limes* of the Empire. Almost all the other stones conserved in the Thermen museum come from Heerlen and generally comfort our conclusions on the trade and milling patterns.

Importing quality rocks is a necessity to follow the mechanical requirements of grinding. This need is peculiarly sensitive during the Roman period in an area devoid of suitable raw materials. Limestones of similar quality to those outcropping around Maastricht have been exploited for quern manufacturing in other parts of the Western Roman Empire (e.g. in Picardy, France: [FRONTEAU *et al.* 2017 in press](#)). Here, however, the intensification of exploitation of the Eifel volcanic flows in Roman times coupled with an extremely developed transport network between the Rhine and Meuse rivers largely promoted the search for the best available rocks. And these materials are available from a distance of just over 100 kilometres south-east of Heerlen (fig. 3).

The basalt-like lava from the Eifel makes up the majority of the querns and millstones in Heerlen and was probably transported either overland from the Mayen workshops or by a combination of overland and fluvial transport: on the Rhine between Mayen and Cologne and then by the main road leading to Bavay and Boulogne (France).

Rocks from the Ardennes saw much more limited use: only one fragment of a large animal driven millstone of true arkose probably coming from the east of the Rocroi massif (Ardennes massif). The Macquenoise sandstone, coming from large quarries located to the west of the Rocroi massif, is only observed on two hand querns without archaeological provenance.

Quern and millstone supply of Heerlen is thus oriented by far from the Rhenish region, as is the case in Tongeren where 86 % of the querns and millstones follow this trade pattern ([HARTOCH *et al.* 2015](#)).

On the technical side, domestic subsistence milling with small hand driven querns remains omnipresent. Yet animal and water mills enable an increase of the scale of cereal transformation and sustain an urban population which does not take part at this stage in activities related to preparing food. Finally, the location of certain large millstone finds downhill the baths of Heerlen can be linked with their water supply, suggesting the presence of several unidentified watermills.

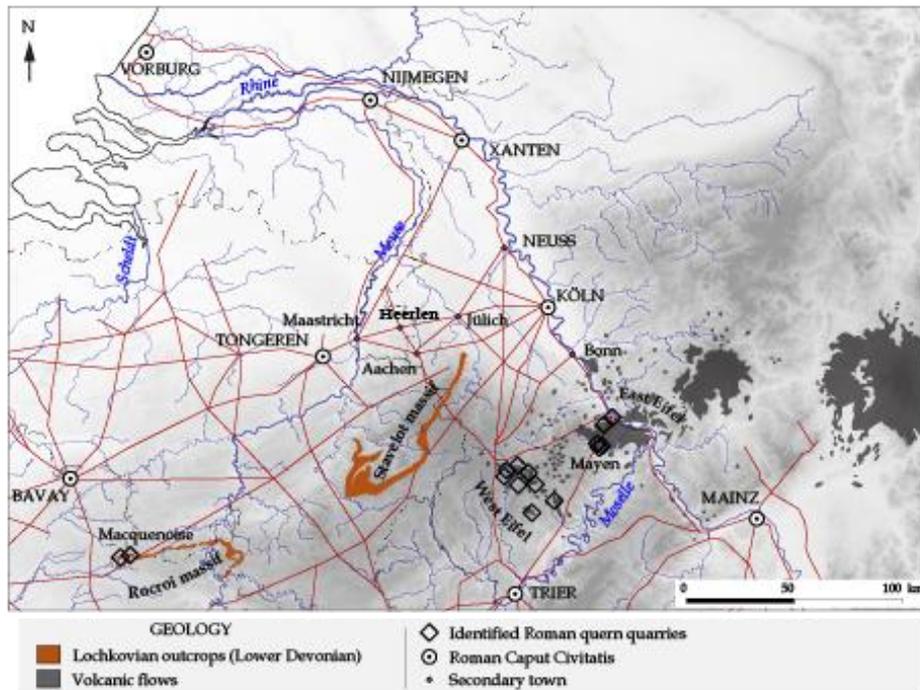


Fig. 3 – Provenance map of the querns and millstones found in the Heerlen bath district. (P. Picavet)

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